Supersolid, a slippery new state of matter,

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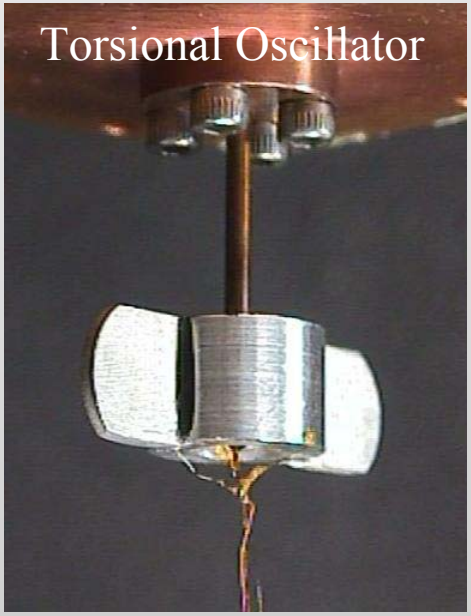
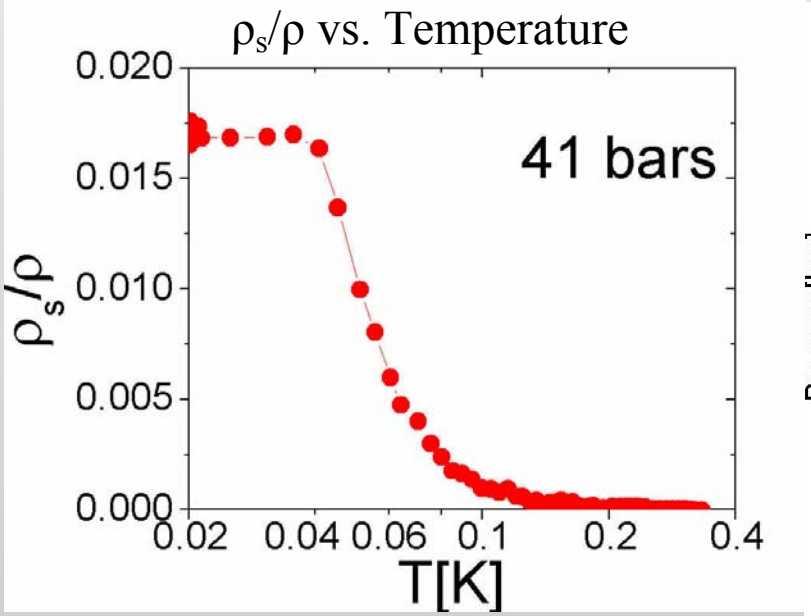
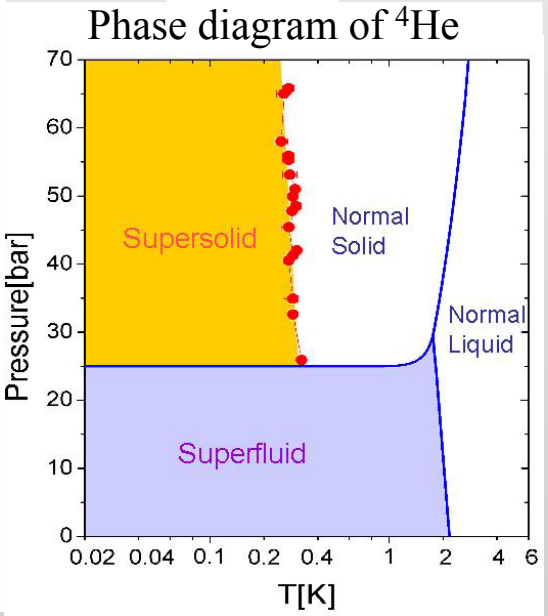
- Solid ^{4}He inside the annular channel in the torsion cell contributes to the rotational inertia and hence increases the resonant period of the torsional oscillation.
- When the cell is cooled below 250 mK, a drop in the resonant period is found indicating that a fraction, about 1.5% of solid ^{4}He is staying still with respect to the motion of the torsion cell and decoupled from the oscillation. This fraction is known as the supersolid fraction, ρ_s/ρ.
- From the viewpoint of the torsion cell, ρ_s/ρ is undergoing oscillatory superflow. Control experiments show the superflow is frictionless. This behavior is similar to that found for liquid ^{4}He in the superfluid phase.
- The supersolid phase is found in bulk solid helium and solid helium confined in porous media indicating that it is an intrinsic property of ^{4}He.







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A defining characteristic of a solid is that it does not flow, in contrast to a liquid. Amazingly, recent experiments at Penn State found that when solid helium-4 is cooled to ultra low temperature, it enters into a new state of matter called supersolid. In this state, a small fraction (1.5%) of the atoms in the solid can flow and flow without any friction past the surrounding atoms. This phenomenon is reminiscent of superfluidity found at slightly higher temperature in liquid helium. The major difference is that superfluidity involves all of the liquid instead of a small fraction as in supersolid.

The phenomena of superfluid and supersolid are closely related to superconductivity found in some metals and some oxide materials. Instead of helium atoms that flow without friction, in superconductivity pairs of electrons flow without electrical friction or resistance.

Commenting on the significance of the Penn State experiment, Nobel laureate Anthony Leggett said, “This experiment will force theorists (theoretical physicists) to revise dramatically the generally accepted picture of crystalline solid helium-4”. Indeed physicists have to rethink the meaning of a solid.

While there is no immediate application of the supersolid phenomenon, our experience with superconductivity suggests that supersolidity may also be of technological importance in the future.

Supersolid, a slippery new state of matter, III: Outreach; DMR-0207071, P.I.: M.H.W. Chan, Penn State

- Three graduate students, Eunseong Kim, Anthony Clark and Xi Lin are receiving rigorous training in low temperature physics. A former student, Gabor Csathy is currently a post-doc at Princeton. Two undergraduates participated in this project. One is currently a graduate student in MIT.
- Our recent discovery of the supersolid phase led to articles and write-ups in magazines such as Physics Today, Physics World, Science News, and Discover. It also received world wide coverage in numerous newspapers, magazines and radio and television programs. The P.I. did a large number of interviews with regard to these articles.
- The P.I. and Eunseong Kim, the graduate student responsible for the supersolid experiment have presented over twenty invited talks on the subject in international meetings, in universities and in undergraduate colleges.